

Jan. 18, 1949.

F. L. MOSELEY ET AL

2,459,177

DIRECT CURRENT AMPLIFIER

Filed March 5, 1945

2 Sheets-Sheet 1

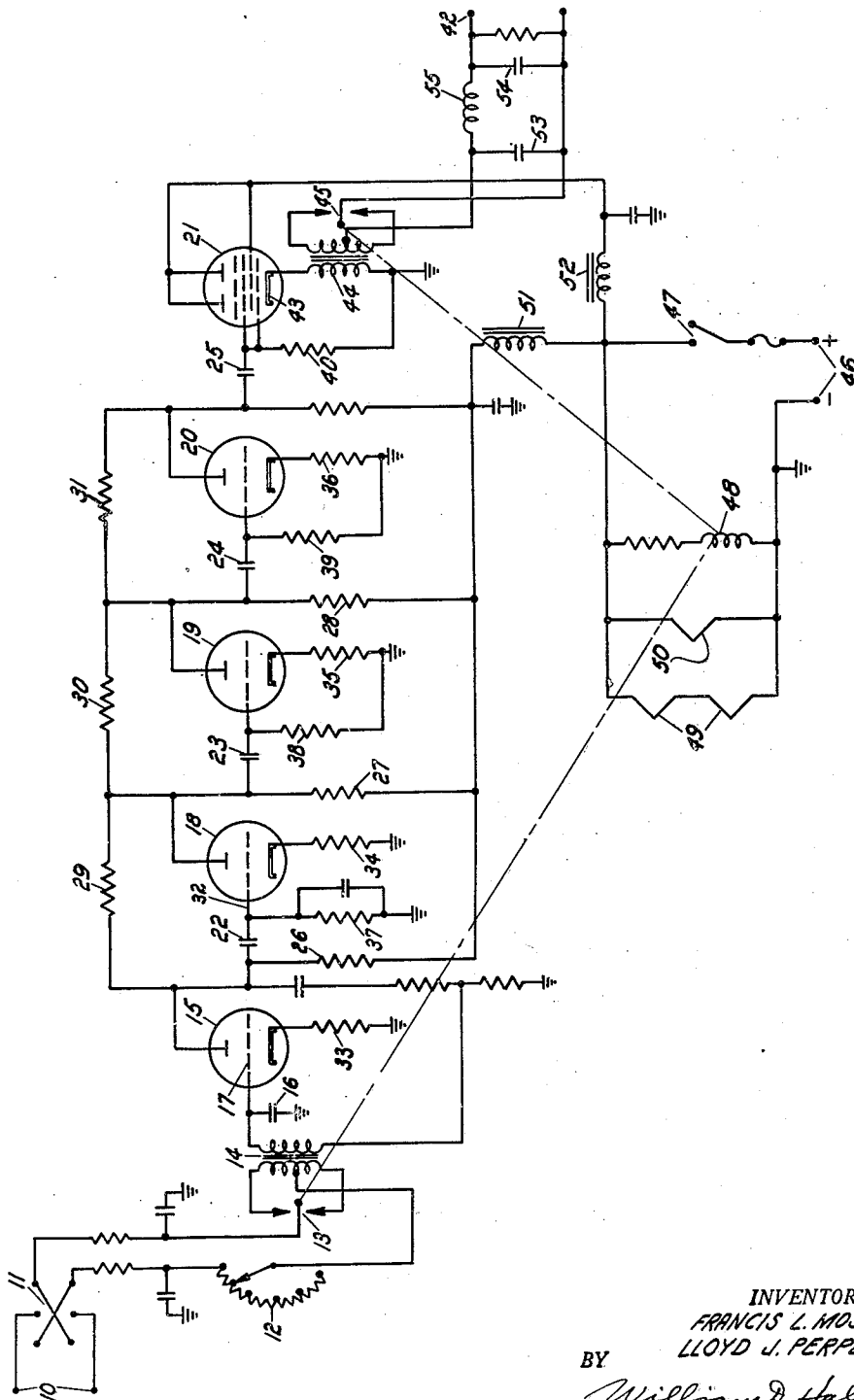


FIG. 1

INVENTOR.
FRANCIS L. MOSELEY
LLOYD J. PERPER
BY
William D. Hall
ATTORNEY

Jan. 18, 1949.

F. L. MOSELEY ET AL

2,459,177

DIRECT CURRENT AMPLIFIER

Filed March 5, 1945

2 Sheets-Sheet 2

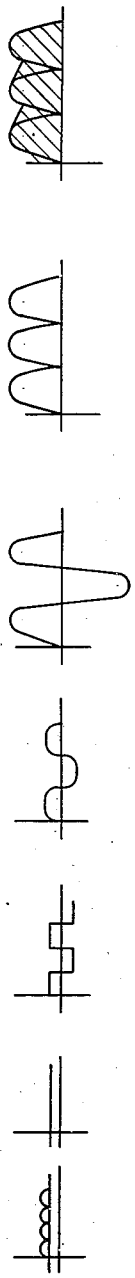
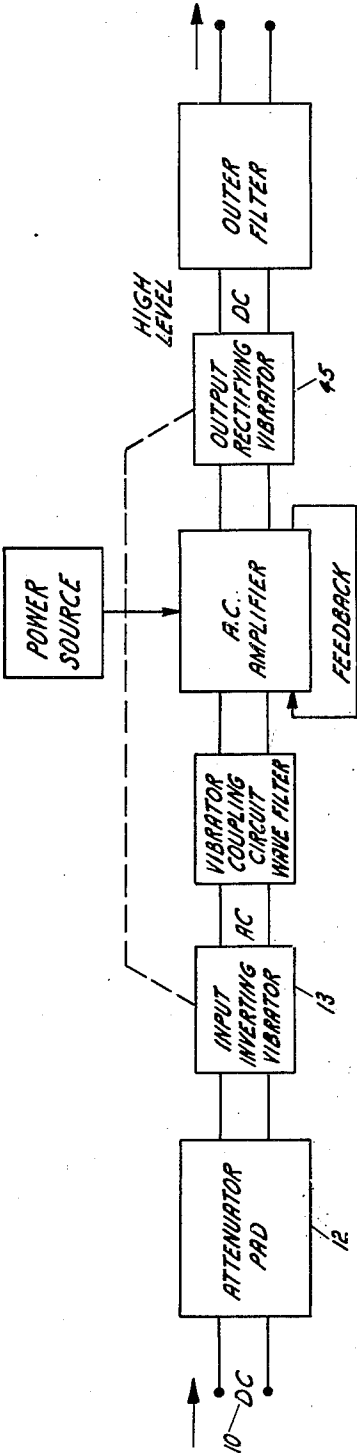


FIG. 2

INVENTOR.
FRANCIS L. MOSELEY
LLOYD J. PERPER
BY
William D. Hall.
ATTORNEY

UNITED STATES PATENT OFFICE

2,459,177

DIRECT-CURRENT AMPLIFIER

Francis L. Moseley, Osborn, and Lloyd J. Perper,
Dayton, Ohio

Application March 5, 1945, Serial No. 581,018

2 Claims. (Cl. 179—171)

(Granted under the act of March 3, 1883, as
amended April 30, 1928; 370 O. G. 757)

1

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to us of any royalty thereon.

The present invention relates to D. C. amplifiers, and is particularly useful in amplifying a low direct current voltage of low power to one of high power.

An object of the invention is to invert weak direct current, amplify the resultant A. C., and then rectify this A. C. to a resultant direct current of greater power to actuate controls, indicators or any mechanical or electrical device requiring more voltage or power than was available in the original input.

A further object is to provide such an amplifier which will utilize simple components, be inexpensive to manufacture and adaptable to mass production technique.

A still further object is to provide such an amplifier which will have automatic gain stability as well as centering stability so that spurious output without input is eliminated.

Another object is to provide such an amplifier which is free from ground connections so as to be easily adaptable to all types of circuits where amplification of D. C. is desired, particularly in airborne recording and control applications where the 28 volt battery voltage may be used without special regulation or step-up to a higher voltage for the plate circuits.

These and other objects will appear throughout the specification and will be particularly pointed out in the claims.

Referring to the drawings wherein like numerals denote like parts,

Fig. 1 is a schematic diagram of the circuit employed in the amplifier; and

Fig. 2 is a block diagram illustrating the functions of elements shown diagrammatically in Fig. 1.

The present invention preferably employs a split read vibrator, the twin reeds vibrating simultaneously because of their unitary spring construction. The function of the reeds is to pulsate the incoming D. C. to A. C., through one section of the reed, whence it is amplified and returned correctly phased to the other section of the reed for rectification. Negative feed back is em-

2

ployed in the various stages of the amplifier to maintain gain stability.

The amplifier is particularly adaptable to the extremely low power outputs of aircraft instruments, receivers and controls. For instance, it has proved effective when used with a cross-pointer instrument landing indicator, the full scale output voltage of which is of the order of 150 millivolts. This voltage after amplification to 2 volts in the present amplifier was applied to operate the stylus of a graphic recorder. In another application the same voltage of the cross-pointer landing indicator after amplification is used to actuate automatic pilot controls and relays for automatically flying and landing aircrafts.

The amplifier may be employed in a wide range of power applications and for many other purposes than herein disclosed and it is understood therefore that no limitation in the embodiment or details of the disclosure is intended other than as contained in the claims appended hereto. By way of illustration, to describe an embodiment of the invention, the D. C. input is first filtered through a filter network to remove any undesirable A. C. ripple and the input is controlled through a series step attenuator in the increments desired. The desired amount of input resistors are also included to avoid loading the line and any reduction in gain therefrom may be compensated by additional amplification.

The amplifier preferably shown includes in its circuit a transformer input coupling and the secondary of this transformer is coupled to the grid of the first tube of the amplifier, the output of which may be resistively or capacitively coupled to several additional amplifier stages. Degenerative feed back between amplifier stages provides a high degree of stability and linearity of amplification.

As will be observed from a study of the schematic drawing, no balancing circuit is included or necessary. The zero position cannot be unbalanced or drift. That is, with zero input there will be zero output. This is a highly desirable characteristic when the amplifier is used for precision measurements and recording. Thus there is obviated a common defect of amplifiers which must depend on a steady D. C. supply voltage or tube characteristics for stability and freedom

from drift. Both current and voltage feed back are employed to minimize effects of variable elements which may be present. The output of the amplifier power tube is derived from the cathode circuit but could equally well be taken from the plate circuit.

The output vibrator forms an output switch through an output transformer. This arrangement permits making and breaking of the output switch in synchronism with the input vibrator, also acting as a make-and-break switch, in several ways. For instance, the contacts may be mounted on the same reed so as to be synchronized mechanically, or they may be separately mounted with their respective vibrating reeds electrically synchronized. Thus, even though the schematic drawing depicts the two vibrators spaced at either end of the circuit, in actual use it will be found highly efficient to mount the contacts on a single vibrating reed by proper insulation, and thereby provide a compact unit employing a single vibrator coil.

In the drawings, the low input D. C. voltage which is to be amplified is introduced from the receiver or other source through input terminals 10, reversing switch 11 and through a stepped attenuator 12 to a pair of vibrator contacts 13 which invert the input D. C. voltage to A. C.; thence through transformer coupling 14 which is preferably center tapped to couple the pulsed A. C. to the first amplifier tube 15. Any other conventional type of coupling can be used in place of transformer 14. The A. C. voltage is impressed on grid 17 of tube 15 for amplification, and the output is successively grid-coupled to the succeeding stages of amplifier tubes 18, 19, 20 and power tube 21. Interstage coupling is illustrated through capacitors 22, 23, 24 and 25. Amplifier tubes 18, 19, 20, 21 are operated as Class A amplifiers and inverse feed back is employed at each stage to improve linearity of output. Again, this desirable feature may be provided or omitted, depending on the degree of gain, stability, or linearity of output required. Resistors 26, 27, 28 also form part of the interstage coupling in conventional manner. Inverse feed back is applied to the individual stages through resistors 29, 30, 31; that is, a portion of the output of tube 18 is applied to its grid input 32, and similarly tubes 19 and 20 feed back a portion of their respective output to their grid input. Current feed back is provided through cathode resistors 33, 34, 35, 36 and output load 42. Grid bias is maintained through grid resistors 37, 38, 39, 40 in conventional manner.

The power output of power tube 21 is shown for illustration purposes, as derived through its cathode 43 and transformer 44. The filtering network such as condensers 53, 54 and inductance 55 may also be provided to filter out undesired output ripple.

The output of transformer 44 is fed to the output vibrator 45 where rectification of the A. C. takes place in synchronism with the input of vibrator 13, by center tapping the secondary of the output transformer 44. Phasing of the amplifier is adjusted through proper values of capacitances and resistances in the circuit so that the output A. C. to the output contacts in vibrator 45 is in phase with the A. C. at the input contacts of vibrator 13. Extraneous power for amplifying the low voltage is injected into the plate circuit of the amplifier tubes through terminals 46 and switch 47. The power supply feeds the vibrator coil 48 which actuates the reed

of vibrators 13 and 45, as indicated schematically by the dot-dash lines in Fig. 1. As heretofore stated these vibrators are preferably of the split reed type wherein the contacts are divided and insulated but mechanically connected. Where separate coils for the vibrators are employed, electrical synchronization of the reeds should be provided to avoid spurious output.

The filaments 49 and 50 of the tubes are likewise illustrated schematically in the power input circuit, and chokes 51 and 52 are employed to filter out unwanted power supply ripple.

Thus it is seen that considerable power may be derived through the novel amplifier with a very small input signal or control voltage and with good linearity characteristics wherein the voltage output is directly proportional to the voltage input. There is no necessity for a centering control because zero D. C. signal input gives zero A. C. signal when inverted by the vibrator, and must give zero signal output when rectified. This novel arrangement, due to its freedom from bucking and balancing tube circuits provides such a degree of centering accuracy that instruments may be calibrated and voltages may be measured directly with full confidence in the accuracy of the measurements. The output may be varied by proportioning the gain components so as to obtain a logarithmic or other desired type of gain. Initial design of the components will determine the type of gain.

The input circuit of this amplifier is completely isolated from the output circuit and there is consequently no likelihood for the output circuit voltage to float above ground at the power supply voltage level and thereby damage circuit components or prevent accuracy of operation.

This amplifier permits the utilization of standard localizer and glide path radio equipment for automatically landing aircraft. In such application a preferred method is to employ a separate amplifier for the glide path receiver voltage source and for the localizer receiver voltage source. And when these units are used in combination with the rate circuit systems of landing such as are described in copending application Number 545,173, filed July 15, 1944, now abandoned, and application Number 542,594, filed June 28 1944, the aircraft controls can be made to respond to the localizer and glide path beams with a fidelity that human pilots admittedly have been unable to duplicate.

Having thus described the invention, what is claimed is:

1. An amplifier system for amplifying low level direct current voltages to high level direct current voltages, comprising a multi-stage alternating current tube amplifier and biased to operate as a class A amplifier, a vibrator having a vibrating reed with a pair of spaced contacts between which the reed vibrates, an input circuit for said amplifier having a transformer whose primary winding is connected across said vibrator contacts, the reed of the vibrator being connected in series between the direct current source to be amplified, and the electric midpoint of said primary winding, whereby zero alternating current voltage appears in the output of the amplifier when zero direct current voltage is at said input, another vibrator having a vibrating reed and a pair of spaced contacts between which the reed vibrates, means coupling said other vibrator to the output of said amplifier for full wave rectification, the vibratory armature of the first-mentioned vibrator being conductively isolated from

direct current ground in the absence of direct current input voltages, and the input terminals of the system and the output terminals of the system being effectively isolated from each other with respect to the passage of direct current. 5

2. An amplifier system according to claim 1 in which each stage of said multi-tube amplifier has its plate circuit back-coupled to its grid circuit for alternating current feedback.

FRANCIS L. MOSELEY. 10
LLOYD J. PERPER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,428,156	Espenschied	Sept. 5, 1922
2,114,298	Gunn	Apr. 19, 1938
2,133,670	Schuchmann	Oct. 18, 1938
2,190,317	Holst	Feb. 13, 1940
2,297,543	Eberhardt	Sept. 29, 1942